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## (54) Device for measuring muscular work and power.

(57) The device for measuring muscular work and power performed in moving loads associated with a gymnastic apparatus is constituted by one or more means (6) which are associated with the gymnastic apparatus (1) and are suitable for measuring the movement of the loads (5) and the time required to achieve the movement. The means (6) are furthermore connected to a device (14) for displaying data such as the muscular power developed during the exercise and the amount of biochemical energy used so as to allow the athlete who is performing the exercises on the gymnastic apparatus to be instantly informed concerning the type and therefore the quality of the muscular work he is developing.

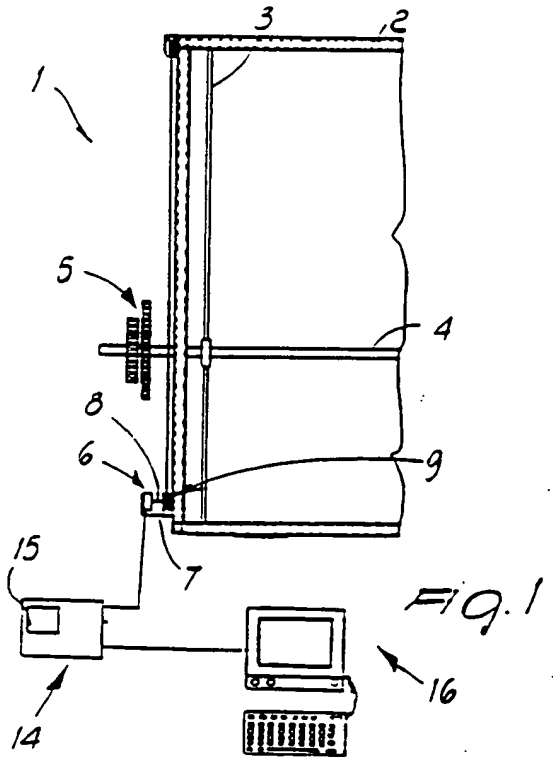


FIG. 1

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The present application relates to a device for measuring muscular work and power performed in moving loads associated with a gymnastic apparatus or on so-called body building machines which use gravity-based loading systems.

The muscular work and power developed during exercise currently cannot be measured qualitatively, in that when a load is lifted the user who performs the movement can only find out the amount of the load, and therefore of the weight, he has lifted.

This is naturally true both when the load is lifted directly by the user, who for example uses a bar, and when the load is lifted or lowered by means of the system of cables and pulleys with constant or variable radius.

The user who is training or rehabilitating on the body building machine or on the gymnastic apparatus thus does not know exactly the type and therefore the quality of the muscular work he is performing.

The various training plans, programmed for example for a patient who must be renabilitated or for an athlete who must train or for a person who wishes to improve his physical condition, are in fact planned and expressed as percentages of the maximum capabilities of the user involved.

The values which are pointed out therefore do not represent the actual loads, in that when one claims to be working at a certain percentage of the maximum value this indication does not indicate the qualitative work performed, since, assuming the maximum value is 100 kg, working at 85% means working with 85 kg, and when one works with a load of 85 kg, from the physiological point of view the effects which are caused can be entirely different depending on how the exercise is performed.

Therefore, if the load is lifted at the maximum speed which it allows, a certain muscular power will be developed by the user; if instead the load is lifted at a slower speed, the development of the muscular power will vary.

In this manner, the biological effects which are caused are completely different from those produced in the first case: in the first case it is in fact possible to obtain an improvement in the neuromuscular qualities, whereas in the second case local metabolic processes (i.e. muscular resistance) will be more stimulated.

The aim of the present invention is therefore to eliminate the disadvantages described above in known types by providing a device which allows to provide the user of body building machines or of gymnastic apparatuses data and recordings related to the type and quality of the muscular work performed and therefore to the physiological effects caused by the training.

Within the scope of the above described aim, another important object is to provide a device which also allows to display and record the biochemical energy used to produce the mechanical work.

Still another important object is to provide a device which associates with the preceding characteristics that of indicating and recording data which allow to identify the metabolic processes in their various forms.

Another important object is to provide a device which associates with the preceding characteristics that of displaying and recording the amount of energy consumed to produce concentric muscular work and eccentric muscular work.

Still another important object is to provide a device which is structurally simple as well as easy and rapid to apply to body building machines or gymnastic apparatuses.

Another important object is to provide a device which associates with the preceding characteristics that of being reliable and safe in use, without requiring particular technical conditions for its use.

Not least object is to obtain a device which has modest costs and is not subjected to frequent maintenance.

This aim, these objects and others which will become apparent hereinafter are achieved by a device for measuring muscular work and power performed in moving loads associated with a gymnastic apparatus or with a body building machine, characterized in that it is constituted by one or more means, associated with said body building machine or rigid apparatus, which are suitable for measuring the movement of said loads and the time used to achieve said movement, said means being connected to a device for displaying data such as the muscular power developed during the exercise and the amount of biochemical energy used.

Further characteristics and advantages of the invention will become apparent from the detailed description of a particular but not exclusive embodiment, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

figure 1 is a schematic view of the components of the device in the particular application to a bar;

figure 2 is a side view of the device shown in figure 1.

With reference to the above figures, the reference numeral 1 indicates a body building machine or a gymnastic apparatus which, in the particular indicated case, is constituted by a framework 2 which has adapted lateral supports 3 for guiding a bar 4 with which loads, constituted by conventional disks 5, can be associated at the ends.

The device for measuring muscular work per-

formed by the body building machine 1 comprises means for measuring the movement of the gravitational load constituted by the bar 4 and disks 5; said means can be constituted by photoelectric cells, infrared-ray devices, accelerometers, optical-fiber systems or in any case known sensing systems which, in the particular embodiment, are indicated by a detector (encoder) 6 which is supported on the framework 2 by means of a first bracket 7 and has a shaft 8 keyed at a first pulley 9 which is rotatably associated with a second bracket 10 rigidly associated with the framework 2.

A tension element, such as a cable or a sheath 11, is associated at the first pulley 9 and interacts with a second pulley 12 which is rotatably associated at a third bracket 13 which is rigidly associated with the framework 2.

Advantageously, the first pulley 9 is associated proximate to the lower end of the framework 2, whereas the second pulley 12 is associated at the upper end of said framework.

The cable or sheath 11 is furthermore connected at the bar 4 so that a vertical movement thereof corresponds to an analogous and equal movement of the cable or sheath 11, this movement being detectable by means of the detector 6.

The device for measuring muscular work furthermore comprises means for displaying and storing the movement imparted to the bar 4; said means are constituted by a unit 14 which is connected to the detector 6, has a display 15 and is internally provided with a central processing unit for the processing of the information from said detector 6.

Said unit 14 therefore allows to also measure the time used by the user to achieve the movement imparted to the gravitational load and to process this datum together with the datum related to the movement.

Advantageously, a computer 16 can be connected to the unit 14 to handle and process the data detected and processed at the unit 14.

During the execution of the exercise and therefore of the lifting of the gravitational load associated with the bar 4, the unit 14 measures, by means of the detector 6, the movement of said load and simultaneously measures the time required to perform this movement.

Formulas which have been observed to give excellent results, even if they are given in a very simple and schematic form, are described hereinafter in the evaluation of the quality of the developed muscular work; the following formulas, in fact, despite their simplicity, have been found to be sufficient to achieve the required result in the specificity of the subject.

Therefore, in considering the mechanical work L performed during lifting, we can consider it to be obtained by multiplying the distance D, covered by the gravitational load, by a force constituted by the mass m of said load multiplied by the acceleration of gravity g, and therefore:

$$L = m \times g \times D.$$

The effect of friction is calculated in computing the work when necessary.

The effect produced by the different torques which are exerted and produced by different lever arms which may be present in a given body building machine is also taken into account during the calculation of the work.

The unit 14 can thus show on the display 15 this datum together with the datum related to the average power P developed in the time interval t used to perform the movement D and therefore: $P = L/t$.

In this manner, during the exercises which the user is performing on the body building machine he can be instantly informed concerning the type of muscular work he is developing by means of the unit 14.

Thus, at each work cycle, a central processing unit, such as a microprocessor, once it has received the information on the movement and the time required to move the load, calculates the amount of work and of average developed power.

These data can be viewed by the person performing the exercise by means of the display 15.

The work of the average power can furthermore be expressed as a percentage of the maximum work of mechanical power performed by the muscles involved in the movement.

Once the average power percentage with respect to the maximum value of mechanical power is known, it is possible to indirectly calculate the type of metabolic process involved during that given muscular contraction.

It is thus possible to quantify the biochemical energy used to produce the work and at the same time to identify the metabolic processes in their various forms.

It is furthermore possible to calculate the amount of energy used to produce concentric (positive) and eccentric (negative) muscular work.

The energy used by the muscles and which derives from distinct metabolic substrates is termed hereinafter "biochemical energy": the amount of said biochemical energy used during muscular contraction can be calculated by considering both the energy used during concentric (positive) work, which is indicated by Lpos, and the biochemical energy used during eccentric (negative) work, which is indicated by Lneg.

The biochemical energy used during concentric work, indicated by Elp, can be calculated according to the following formula: $Elp = Lpos \times A$, where the coefficient A can assume values com-

prised between a minimum of 5 and a maximum of 10.

The amount of biochemical energy used during eccentric work, indicated by Ein, can be calculated with the following formula: Ein = Lneg x B, where the coefficient B can assume values comprised between a minimum of 0.60 and a maximum of 2.00.

The device can also evaluate the maximum power which a given muscle or group of muscles can develop.

In order to obtain this, it is sufficient to measure the power during exercises in which minimum and maximum loads are used: the load with which the muscle or muscles are able to express the maximum power is thus obtained empirically.

Said maximum power can be indicated as 100% x 100% of maximum power.

Therefore, every time the person performs an exercise and therefore muscular work, the device, by means of the unit 14, calculates the value as a percentage of the maximum power.

In this manner the person can receive a visual or acoustic item of information which informs him concerning the amount or quality of the muscular work produced, and is therefore automatically informed concerning the type of biochemical energy which he is using during contraction.

It has thus been observed that the invention has achieved the intended aim and objects, a device having been provided which allows to qualitatively measure the muscular work performed during exercises performed on body building machines which use gravitational load systems.

The subject of the present invention is naturally susceptible to numerous modifications and variations, all of which are within the scope of the inventive concept.

The materials and the components of the device may also naturally be the most appropriate according to the specific requirements or to the particular body building machine used.

Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

## Claims

1. Device for measuring muscular work and power performed in moving loads associated with a gymnastic apparatus or with a body building machine, characterized in that it is constituted by one or more means (6) which are associated with said body building machine (1) or with said rigid apparatus and are suitable for measuring the movement of said loads (4,5) and the time required to achieve said movement, said means being connected to a device (14) for displaying data such as the muscular power developed during the exercise and the amount of biochemical energy used.

2. Device according to claim 1, characterized in that said body building machine or gymnastic apparatus is constituted by a framework (2) which has adapted lateral supports (3) for guiding one or more gravitational loads, such as a bar (4) with which loads, constituted by conventional disks (5), can be associated at the ends.

3. Device according to claims 1 and 2, characterized in that it comprises means (6) for measuring the movement of said gravitational load, said means being possibly constituted by photoelectric cells, infrared devices, accelerometers, optical-fiber instruments or in any case sensing systems.

4. Device according to claims 1 and 3, characterized in that said means are constituted by a detector (6) , also known by the term "encoder", which is supported on said framework (2) by means of a first bracket (1) and has a shaft (8) keyed at a first pulley (9) which is rotatably associated with a second bracket (10) rigidly associated with said framework (2).

5. Device according to claims 1 and 4, characterized in that a tension element (11), such as a cable or sheath, is associated at said first pulley (9) and interacts with a second pulley (12) which is rotatably associated at a third bracket (13) rigidly associated with said framework (2).

6. Device according to claims 1 and 5, characterized in that said first pulley (9) is associated proximate to the lower end of said framework (2), said second pulley (12) being associated at the upper end of said framework (2).

7. Device according to claims 1 and 5, characterized in that said tension element (11) is connected to said gravitational load (5) or to said bar (4) so that a vertical movement of the latter corresponds to an analogous and equal movement of the former which can be detected and measured by means of said detector (6).

8. Device according to claims 1 and 7, character-

ized in that it comprises means for displaying and storing the movement imparted to said gravitational load or bar, said means being constituted by a unit (14), connected to said detector (6), which has a display (15) and is internally provided with a central processing unit for information processing.

9. Device according to claims 1 and 8, characterized in that said unit (14) counts the time used by the user to achieve the movement imparted to said gravitational load (5) and processes this datum together with the one related to movement, a computer (16) being connectable to said unit (14) for handling and processing the data detected and processed at said unit (14).

10. Device according to claims 1 and 9, characterized in that during the execution of the exercise and therefore during the lifting of said gravitational load (5) said unit (14) and/or computer (16) processes the datum related to the movement of said load (5) together with the evaluation of the time used to achieve said movement in order to achieve the computing of the mechanical work performed, of the average power developed, possibly expressed as a percentage of the maximum work of mechanical power performed by the muscles involved in the movement and the type of metabolic process involved during that given muscle contraction by means of the quantification of the biochemical energies used, this allowing to identify the metabolic processes in their various forms.

11. Device according to claims 1 and 10, characterized in that said biochemical energy is constituted by the energy used by the muscles and which derives from distinct metabolic substrates, the amount of said biochemical energy being calculated by considering both the energy used during concentric (positive) work, indicated by Lpos, and the biochemical energy used during eccentric (negative) work, indicated by Lneg.

12. Device according to claims 1 and 11, characterized in that said biochemical energy used during said concentric work, indicated by Elp, is obtained according to the following formula: Elp = Lpos x A, said coefficient A assuming values comprised between a minimum of five and a maximum of ten.

13. Device according to claims 1 and 12, characterized in that the amount of said biochemical energy used during said eccentric work, indicated by Eln, can be obtained according to the following formula: Eln = Lneg x B, said coefficient B assuming values comprised between a minimum of 0.60 (zero point sixty) and a maximum of 2.00 (two).

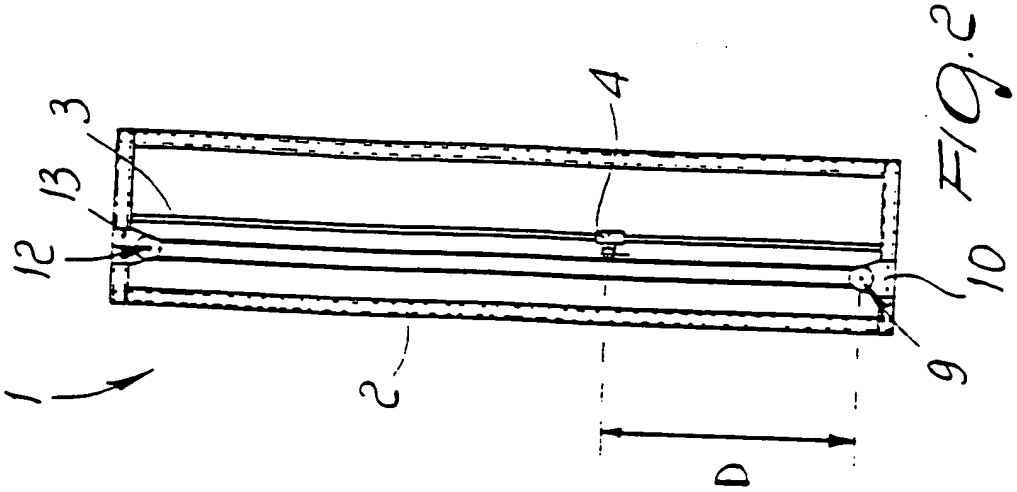


FIG.2

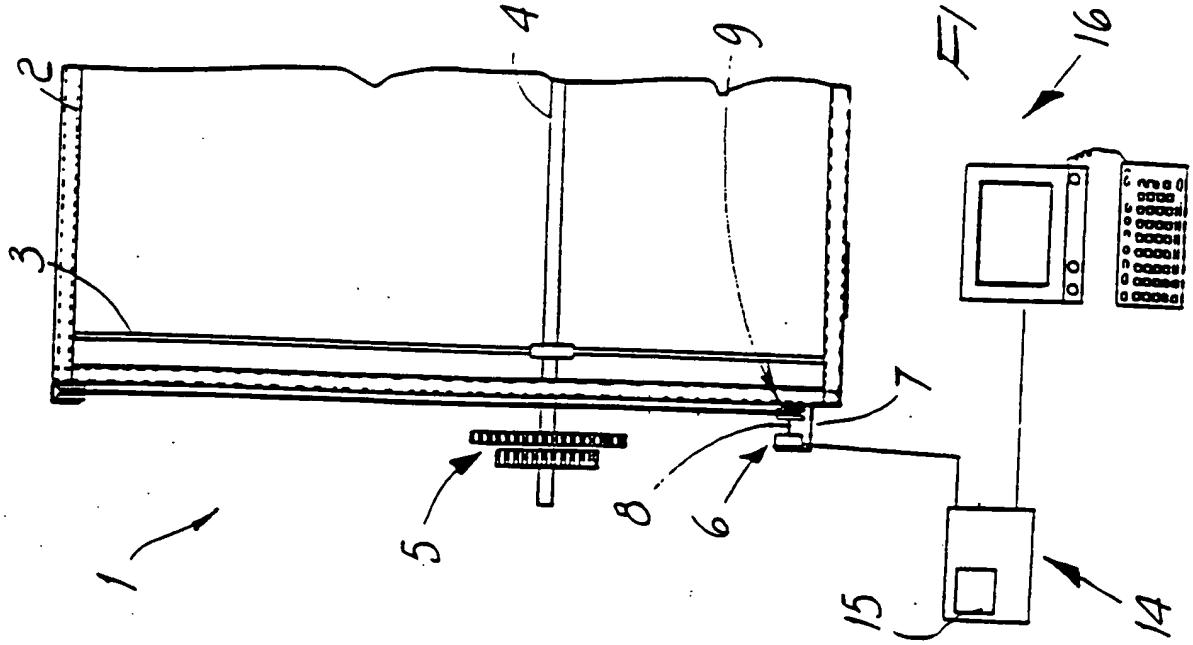


FIG.1

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number

EP 91 10 2723

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
|---|---|---|---|
| X,A | DE-U-8 801 538 (V. WACK et al.)<br>* Complete document * | 1-3,8 | A 63 B 21/06<br>A 63 B 24/00 |
| X | DE-U-8 502 372 (M. KEILBACH)<br>* Figures 1a,2a; page 7, last paragraph; page 9, paragrapns 3,5 * | 1-3,8 | |
| X | DE-A-3 914 437 (H. LEUTHEUSER)<br>* Page 2, claims 6,7,9,10,11 * | 1,3 | |
| A | WO-A-8 101 507 (B. SVENSSON)<br>* Page 2, line 20 - page 3, line 22 * | 3,8-11 | |
| X | DE-C-3 807 038 (P. BEUTEL)<br>* Column 3, lines 30-55 * | 1-3 | |

| TECHNICAL FIELDS SEARCHED (Int. Cl.5) |
|---|
| A 63 B |

The present search report has been drawn up for all claims

| Place of search | Date of completion of search | Examiner |
|---|---|---|
| The Hague | 06 June 91 | VEREECKE A. |

CATEGORY OF CITED DOCUMENTS

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